ARIZONA TRANSPORTATION RESEARCH CENTER

RESEARCH NOTES:

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DEVELOPMENT AND IMPLEMENATION OF ARIZONA DEPARTMENT OF TRANSPORTATION (ADOT) PAVEMENT MANAGEMENT SYSTEM (PMS)

BACKGROUND

The Arizona Department of Transportation (ADOT) pavement management system (PMS) is used to allocate expenditures on pavement preservation. Data is collected annually on roughness, skid, cracking, rutting and flushing. This data is entered into the PMS system to allocate resources and to provide input into the pavement design function. One of the data fields that the PMS uses in project selection is the average maintenance expenditure per year. The expenditure is obtained from uploading data from the PECOS system.

The PMS system provides a continuous database of pavement performance for the state network.

Maintenance activities, such as preventive maintenance, are all recorded in the PECOS system. PECOS is a resource allocation system that tracks labor, materials and equipment. It does not track the outcome of the activity such as pavement performance for preventive maintenance activities.

There currently is no maintenance process by which outcomes, such as improved pavement performance, can be measured except through personal observation by the individuals applying them.

There is a need to develop a system that allows evaluation of the outcomes of maintenance activities so that their cost effectiveness can be determined and used in development of pavement preservation strategies.

OBJECTIVES OF THE PROJECT

The objective of this research is to develop a enhanced pavement management system that provides the ability to measure the outcomes of the pavement related maintenance activities.

The minimum following activities will be performed:

1. Evaluate the measures of effectiveness necessary to demonstrate the effectiveness of pavement preservation activities.
2. Canvass other states for their procedures for managing the effectiveness of pavement activities.
3. Review the available pavement management systems and asset management systems for application to the maintenance function.
4. Recommend the preferred system/PMS enhancement for use.
5. Develop a working system for delivery to ADOT.

6. Develop an operations manual for using the system.

DEVELOPMENT OF THE ENHANCED PAVEMENT MANAGEMENT SYSTEM

The overall approach followed to achieve the project objectives is divided into four main phases, which are:

1. Development of a Conceptual Design and Layout
2. Structure and Develop Pavement Management Database and Models
3. Conduct State-wide Analysis
4. Install HPMA, train ADOT staff, and provide software technical support

The development of the conceptual plan involved assessing the old ADOT database structure and data elements, identifying the needs of the various system users and determining the availability, relevance and method of importing the data items. The types of the available data were reviewed in terms of the sources, reliability, and level of necessity. This task also involved reviewing the models and parameters used in the Department's current pavement management system. Based on this review, a detailed conceptual plan for the development of ADOT HPMA was developed.

The second phase of the project was directed towards loading ADOT's data into the HPMA database, modifying some of the HPMA functions and adding more functions to meet ADOT requests, and developing the required analysis models. Data loading and model development were carried out based on the conceptual plan developed in Phase 1 of the project and the feedback received from the Technical Advisory Committee. Data was loaded from the existing data sources in ADOT and converted as necessary. The HPMA code tables were first populated and then the data was loaded as required. ADOT requested a number of modifications and enhancements to the functionality of the HPMA software, which were implemented in this phase of the project. These modifications included the inclusion of the maintenance history in the priority rating, modifications to some of the table structures, adding some additional reports and others. The HPMA models and parameters including the condition indices, pavement types, distress types, rehabilitation and maintenance treatments, and decision trees, were developed at this stage.

The completed ADOT HPMA is a single software application that provides full database management and analysis capabilities required by the two types of users (PMS and Maintenance). The HPMA provides capability for users to work at both the detailed highway level and the aggregated section level. Also it provides a wide variety of analysis capabilities, including corrective maintenance, preventive maintenance, and rehabilitation analysis.

When the ADOT HPMA was completed, a statewide analysis to demonstrate the analysis modules in the system was carried out using historic ADOT data. The analysis included identifying ADOT's network budgetary needs and network performance using historic data and comparing these results to actual measured performance data. The results of the analysis showed that ADOT HPMA successfully modeled the historic trends of ADOT pavements and accurately represented ADOT's network conditions.

To demonstrate ADOT HPMA software performance and verify the analysis settings and models in the software, two sets of analyses were performed using the ADOT HPMA. The analyses were performed starting from the year 2000. Thus, the performance data from the following years were not considered in the analysis. The analysis results were subsequently evaluated against the actual data from the years 2000 through 2003.

OVERVIEW OF HPMA SOFTWARE

The ADOT HPMA includes four subsystems namely: the Database Subsystem, the Network Analysis Subsystem, the Engineering Feedback Subsystem, and the Project Design and Analysis Subsystem.

Database Management Subsystem
The HPMA database utilizes a two level structure to serve the required pavement management functions, which are a detailed highway database and a summarized sectional database.

All data types are loaded to the detailed highway database, as well as including all historical records. All detailed highway data items are referenced by physical location using the existing route identifier and milepost reference system defined within ADOT HPMA. The types of detailed data maintained in the database include: inventory, traffic, pavement structure, history, maintenance activities and performance data.

The HPMA database subsystem provides several key functions. These functions include specific tools for performing the basic database management capabilities such as storage and update of highway attributes, browse, and edit functions. Also, functions to perform queries and calculate summary statistics are available in the subsystem.

Network Analysis Subsystem
The purpose of the network level analysis procedures is to determine the current and future maintenance and rehabilitation needs and to develop priority programs to implement the appropriate treatments. The Network Analysis Subsystem provides two types of analysis procedures, namely: the "Maintenance Analysis" and the "Maintenance and Rehabilitation Analysis", or "M&R Analysis". The "Maintenance Analysis" procedure provides a one-year program of maintenance activities based on the detailed analysis of distresses. The "M&R Analysis" procedure, on the other hand, provides multi-year work programs that can incorporate both maintenance and rehabilitation activities.

Maintenance Analysis Procedure
Two types of maintenance analysis are available in ADOT HPMA, which are:

- Maintenance Needs Analysis
- Maintenance Budget Analysis

The maintenance needs analysis uses the detailed surface distress data to estimate the demand-based maintenance needs for contract estimation purposes. This is based on maintenance standards that define the activities required in the next two years to fix the observed surface deficiencies. The observed distress data is compared to the maintenance standards to determine the actual requirements.

The maintenance budget analysis uses the output of the maintenance needs analysis and user defined budget constraints to generate a maintenance work program. In this program, sections and the recommended treatments are selected based on the highest cost-effectiveness. Effectiveness is expressed as a function of the improvement in the surface distress index that should be observed after fixing the distress.

Maintenance & Rehabilitation Analysis Procedure
The Rehabilitation Programming Subsystem provides the following capabilities:

- Rehabilitation needs analysis
- Rehabilitation alternatives analysis
- Rehabilitation programming and budgeting analysis

The rehabilitation needs analysis is used to predict section performance in terms of the individual performance indices and to determine

the present and future rehabilitation needs. The rehabilitation alternatives analysis involves the strategy screening, performance predictions, and economic analyses of the rehabilitation alternatives.

The rehabilitation programming and budgeting analysis provides two main functions, which are developing rehabilitation work programs based on budget constraints and determining the effects of various funding levels on the network performance and needs backlog (or conversely, determining the required budget levels to provide given levels of service).

The optimization analysis includes two modes of operation:

- Effectiveness-maximization, where the optimal work programs are determined based on given funding levels
- Cost-minimization, which provides a means of determining required funding levels to achieve specific performance levels

Funding scenarios can be evaluated by running the analysis in the effectiveness maximization mode with the different funding levels as input constraints. Service level scenarios can be evaluated by running the analysis in the cost-minimization mode with the service levels as input constraints in terms of required performance.

Engineering Feedback Subsystem
The Engineering Feedback Subsystem provides information feedback for evaluating the effectiveness of achieving technical goals, and includes the following capabilities:

- Analysis of pavement performance trends providing feedback for updating the performance prediction models
- Evaluation of the effectiveness of specific maintenance and rehabilitation alternatives in achieving technical goals such as minimum expected life, extension of service life, reduction in rutting, etc.
- Determination of distress trends

Within this subsystem, the maintenance and rehabilitation treatment effectiveness analysis provides the capability to evaluate the effectiveness of specific activities in terms of performance and cost for a specific group of sections.

Project Design & Analysis Subsystem
The Project Design & Analysis Subsystem provides a means of performing project-level Life Cycle Cost Analysis (LCCA).

Typically, detailed design alternatives for selected projects are evaluated based on life cycle costs and effectiveness. Results of FWD analysis along with surface distress, rutting and roughness data, are used in this evaluation. The user has the option of selecting the alternative design with highest cost-effectiveness, the lowest life cycle cost or the lowest user delay.

The full report: DEVELOPMENT AND IMPLEMENTATION OF ARIZONA DEPARTMENT OF TRANSPORTATION (ADOT) PAVEMENT MANAGEMENT SYSTEM (PMS) by Sameh Zaghloul, Khaled Helali and Wael Bekheet, Stantec Consulting Inc. (Arizona Department of Transportation, report number FHWA-AZ-06-494, published April 2006) is available on the Internet. Educational and governmental agencies may order print copies from the Arizona Transportation Research Center, 206 S. 17 Ave., MD 075R, Phoenix, AZ 85007; FAX 602-712-3400. Businesses may order copies through ADOT's Engineering Records Section.